Status of razorback sucker in Lakes Mohave and Mead: A conservation genetic perspective

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Funded by:
Background

- Federally listed as endangered in 1991
- 50+ yrs no natural recruitment in Lake Mohave
  - Water development
  - Non-native fish predation and competition
History of population declines

- Reservoirs fill
  - Populations expand

- Introduction of non-native species
  - Failure to recruit
  - Populations senesce and disappear
  - Demise hastened by large predators
Impact on genetic diversity

- Genetic diversity decreases with population size
  - Can have negative effects on health of population (e.g., inbreeding depression)
  - Can be used to monitor population size
Objective

• Use molecular markers (microsatellites, mtDNA) to monitor levels of genetic diversity in Lakes Mohave and Mead
Lake Mead

• Essentially extirpated in the 1970s
• Re-appeared in late 1980s – early 1990s
  – Unlike other locations subadults have been found
• Goal
  – Assess patterns of genetic variation
What’s happening in Lake Mead?

- Change in sampling
  - Hiatus between 2002 and 2011
  - Additional locations after 2011

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Year</th>
<th>Adults</th>
<th>Larvae</th>
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<tbody>
<tr>
<td>FMS</td>
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<tr>
<td>Mohave</td>
<td>2000/2011</td>
<td>50</td>
<td>120</td>
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<tr>
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<td>early 90s</td>
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</tr>
<tr>
<td></td>
<td>2014</td>
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<tr>
<td></td>
<td>2015</td>
<td>7</td>
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<td></td>
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<tr>
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<td></td>
<td>2015</td>
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<tr>
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<td>2015</td>
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Assignment testing

• Identified three forms
  • Flannelmouth
  • Mead specific form
  • Broadly distributed form (including Mohave)
Assignment testing

- Hybrids most common in the CRI
- Mead specific form (B) most common in EB and OA
Assignment testing

• Hybrids predominate in larvae from CRI
• Mead form (A) most common in OA
Relatedness

- Higher than original measure from Lake Mead and Lake Mohave
- Reduced in 2014 and 2015 (relative to 2011-13)

What about variation among populations?
Similarity of samples
Conclusions
Lake Mead

• RBS in Lake Mead diverging from Lake Mohave
  – Impact of drift due to small population size?
  – As exemplified by flannelmouth-razorback hybrids, increased influx from Grand Canyon?
  – Other geographic effects?

• Because of reduced genetic diversity and change in the population, developing plans to augment with Mohave stock while preserving Mead variation
Lake Mohave Conservation plan

- Initiated in mid-1990’s
- Capture naturally produced larvae
  - across regions
  - throughout the spawning season
- Monitor variation in these samples
Sampling

• 19 years worth of data!!!
• Larvae (1997-2015)
  – 331 collections, 8154 individuals
  – Temporally and geographically dispersed
• Adults
  – 305 wild fish
Genetic variation within larval samples over time

- microsatellites
  \[ R^2 = 0.05, \; P = 0.373 \]
- mtDNA
  \[ R^2 = 0.60, \; P < 0.001 \]
- Allelic richness is being maintained or increased over time
  - Decline in 2015 for mtDNA
Distribution of mtDNA variation among larvae, wild adults, and repatriates

<table>
<thead>
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<th>SOURCE</th>
<th>FST</th>
<th>FSC</th>
<th>FCT</th>
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<tbody>
<tr>
<td>Among samples</td>
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<tr>
<td>Among samples within life stages</td>
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<tr>
<td>Among larvae, wild adults, repatriates</td>
<td>-0.001</td>
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</tr>
</tbody>
</table>

No differences among larvae, repatriates, and wild adults!
Riverine population from Lake Mohave

- Started to sample riverine stretch above Willow Beach
  - 2014 and 2015

- Comparable levels of variation to samples found in Lake Mohave
  - 2014 – 12 haplotypes
  - 2015 – 16 haplotypes
  - Main basin – 14.6 haplotypes (ave 2011-15)
Test of geographic differentiation

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>$F_{ST}$</th>
<th>$F_{SC}$</th>
<th>$F_{CT}$</th>
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<tbody>
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<td>Among years within locations</td>
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<td>0.003</td>
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<tr>
<td>Between the main basin and riverine stretch</td>
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<td></td>
<td>-0.001</td>
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</table>

No difference between riverine reach and main basin
Conclusions: Lake Mohave

• All measures of genetic variation consistent among samples of larvae and repatriates
• Variation is being transmitted from larvae to repatriates
• Increasing levels of mtDNA variation over time
  – Notable decline in 2015
Conclusions: Riverine population

• Riverine population comparable to that in the main basin

• Important to incorporate these fishes into the program

• How?
  – Treat it as a fifth spawning region (comparable to Tequila, Yuma, Nine Mile, and above Owl Point)
  – Supplement the dwindling sample from above Owl Point
Population size

- Despite all of our efforts, population size continues to be an issue

- Problem - ability to maintain genetic variation is constrained by population size

- Will eventually lead to a decline in variation
  - Responsible for the decline observed in 2015?
Major Issue
Stocking size

- Size at stocking is critically important
  - 45 cm fish having a survival rate an order of magnitude higher than 35 cm fish
Major Issue
Stocking size

• Makes more sense (biologically and economically) to stock larger fish!

• There has been movement in this direction

• It will be interesting to see the impacts of this approach in the next few years